ONR Grant #N00014-91-J-1540

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P.I.: Colin F. Mackenzie, M.D.
Tel: (410) 706-3418
E-MAIL Colin@anesth_lab.ab.umd.edu
FAX: (410) 706-2550

Title: Development and Enhancement of a Model of Performance and Decision Making Under Stress in a Real Life Setting

Institution: University of Maryland at Baltimore and
Maryland Institute for Emergency Medical Systems

Current staff with percent effort of each on project:

Colin F. Mackenzie	22%	Peter Hu	5%
William Bernhard	5%	Paul Delaney	5%
Cliff Boehm	5%	Denise Ovelgone	50%
Yan Xiao	30%	Robert Durocher	50%
John Wesolowski	5%	Ben Harper	50%
Sandy Hunter	5%	Sub-contract Man-Made Systems Corp.	
Andy Trohanis	5%		
Jim Brown	5%	Richard Horst	20%
		David Mahaffey	33%

Annual Report Summary for ONR Grant # N00018-91-J-1540

1. Brief Overview

We have concentrated our analysis on 50 of over 100 videotapes acquired of trauma patient resuscitation and anesthesia. The management of the airway (tracheal intubation) in these 50 videotapes was classified into three types of situations: emergency (< 10 min after patient admission), semi-emergency (< 30 min after patient admission) and elective. Such a classification allowed us to contrast the impact of stress on performance and team activity. The following data were collected and analyzed under this classification: (1) Subjective ratings of stress made every minute for 10 min before (when available) during and for 10 min after tracheal intubation. (2) Transcription and coding of communications occurring during same time period. (3) Plotting of patient vital signs and identification of points where previously constructed decision-trees are activated. (4) Acquisition of anesthesia care providers' heart rate and rhythm electrocardiograms and ambulatory blood pressure monitoring of anesthesia care providers during provision of elective and emergency airway management and non-anesthesia activities. (5) Task analysis of tracheal intubation and identification of task omission, task shedding, relationship with subjective ratings of stress and performance of tracheal intubation. (6) Inter-rater reliability analysis of subjective ratings of stress and neural network prediction of perceived stress from weighted combination of subjective ratings of stress. (7) Comparison of errors identified by videotaping and self-reports including the anesthesia record, anesthesia quality assurance reports and the questionnaire completed immediately after videotaping. (8) Examining Task Complexity and its implication for team coordination using data from the post-trauma questionnaire we analyzed task conditions in emergency and non-emergency circumstances. (9) Extracting patterns of team coordination and identifying major decision points through activity analysis.

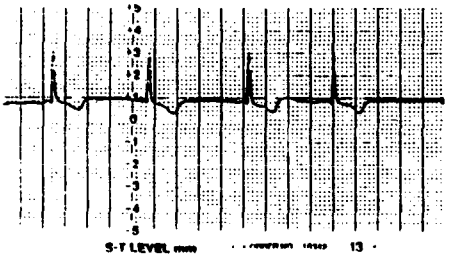
As a result of these analyses, we have illustrated several factors that may have contributed to untowarded incidents[1,3], identified the impact of task complexity on team coordination patterns[8], and investigated the linkage between task performance and communication failures[2]. We found that compared to other means of incident reporting (e.g. post-trauma questionnaire and quality assurance report), video analysis has the advantage of identifying the root causes of errors[5,9]. Through artificial neural network simulation and inter-rater reliability analysis, three subjective ratings were found to be reliable indicators of stress: time pressure, workload and uncertainty. Currently, we are primarily focusing on activity analysis to test several models of team coordination and decision-making, and on the analyses of differences between expert and novice performance and examination of recovery from errors.

2. High-lights of accomplishments

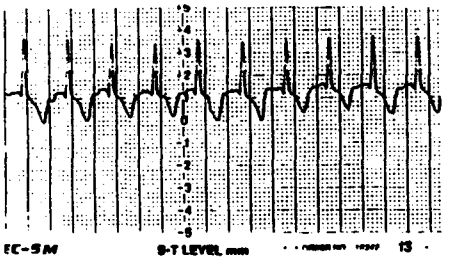
(1) Physiological responses to stress in real environment.

Anesthesia care providers were asked to wear Holter (ambulatory electrocardiographs) and blood pressure monitors during trauma patient resuscitation. We have observed dramatic differences in both heart rate and blood pressure between cases where patient conditions were life-threatening and those cases where conditions were not so (Fig. 1). Currently more physiological data of the anesthesia care providers are being collected and analyzed.

Ambulatory monitoring of physiological data of practitioners in real life situations is difficult, but it provides critical information about the impact of stress and the base for evaluating subjective assessment of stress. The data we have collected reflect the response of anesthesia care providers to stress caused by real-life experience, and are thus particularly valuable.



HR 63/min
BP 122/75
ELECTIVE
NON-EMERGENCY
AIRWAY MANAGEMENT



HR 156/min
BP 156/106
EMERGENCY AIRWAY
MANAGEMENT

HOLTER MONITOR + AMBULATORY BP

MONITORING OF ATTENDING ANESTHESIOLOGIST

Fig. 1. Ambulatory electrocardiogram monitoring of an anesthesiologist during elective tracheal intubation (top panel) showing normal blood pressure and heart rate. The same anesthesiologist two hours later dealing with an emergency intubation has over twice the heart rate (lower panel) and clinically significant diastolic hypertension.

(2) Video analysis as an effective tool for diagnosing root causes of human errors.
Human errors have been blamed as the cause of many accidents, but eliminating human error and alleviating the impact of errors is a challenge. One approach is to diagnose the root cause of these errors, be they ergonomic, social, training-related, or organizational.

We compared the results of video analysis with three types of records that can be used for incident investigations: post-trauma questionnaire (filled by anesthesia care providers immediately after each case), anesthesia record (on-line logs of anesthesia care), and anesthesia quality assurance reports, and evaluated the values of each as a tool to diagnose the root causes of errors. Fig. 2 is the summary of the comparison.

The results of the comparison show that video analysis can be used to identify some of the root causes (which we termed "system failures") of human errors, whereas self-reports, on-line logs, and quality assurance reports provide little information on potential problems in areas such as training, equipment, and social factors (e.g. production pressures).

Given the advances in video recording technology, this finding provides us with adequate justification for using video analysis as a means to diagnose causes of human errors and to make systems more reliable and more efficient.

(3) Meeting series on Team Performance Analyzing Techniques (TPAT).
We held a series of 4 meetings in the Anesthesiology Research Laboratories at the University of Maryland to which we invited researchers working in the area of team performance in stressful environments. The participants included (alphabetical order) Richard Botney, Michelene Chi, Susan Chipman, David Gaba, Joan Hall, Richard Horst, Susan Kirschbaum, Colin Mackenzie, Judith Orasanu, Daniel Serfaty, Gray Wanye, and Yan Xiao. The themes of each TPAT meeting were different and related to video analysis techniques, inter-rater reliability assessment, communication analysis and decision modelling. We prepared a white paper summarizing each meeting. As a result of these meetings two successful collaborations occurred. The first was with Judith Orasannu of NASA and the second with Daniel Serfaty of AlphaTech. Pre-proposals have been submitted to NASA and ONR for possible funding of these collaborations.

Publications during reporting period

1. Mackenzie, C.F., Horst, R.L., Mahaffey, D.L. and LOTAS. Group Decision-Making during trauma patient resuscitation and Anesthesia. Proc. Human Factor and Ergonomics. Soc. 37th Ann Meeting, 1993, pp 372-376.

2. Mackenzie, C.F., Horst, R.L. and LOTAS. Team Communications reveal the root causes of performance problems observed in Airway Management of trauma patients. Proc. of 12th Triennial Congress of the International Ergonomics Ass. Vol 5, pp 65-67, 1994.

3. Mackenzie, C.F., Craig, G.R., Parr, M.J., Horst, R. and LOTAS. Video Analysis of Two Emergency tracheal intubations identifies flawed Decision-making. Anesthesiology 81:763-771, 1994.

4. Hunter A., Mackenzie, C.F., Jefferies, N., Wesolowski, J., Bernhard, W. and LOTAS. Video-analysis of tasks performed during Emergency, Semi-Emergency and Elective Intubation of Trauma Patients. Anesthesiology 81:A626, 1994.

5. Jefferies, N.J., Hunter, A., Bernhard, W., Mackenzie, C.F., Horst, R. and LOTAS. Incidence of procedural errors and untoward occurrencies associated with tracheal intubation assessed from video tapes and self-reports. Anesthesiology 81:A1211, 1994.

Under Review - Submitted

6. Mackenzie, C.F., Hu, P.F-M., Horst, R.L., and LOTAS. An audio-video acquisition system for automated remote monitoring in the clinical environment. J. Clin Monit.

7. Nolan, J.P., Parr, M. J., Grande, C.M., Mackenzie, C.F. and LOTAS. Anesthesiologists and Trauma Patient Resuscitation: A Survey of Level 1 Trauma Centers: Anesth Analg.

8. Xiao, Y., Hunter W.A., Mackenzie, C.F., Jefferies, N.J., Horst, R. and LOTAS Task complexity in Emergency Medical Care and its implications for Team Coordination: Human Factors.

9. Mackenzie, C.F., Jefferies, N.J., Hunter, A., Bernhard, W., Xiao, Y. and LOTAS. Identifying Systems Failures: An analysis of errors in Airway Management as captured by video and self-reports: Human Factors.

INVITED PRESENTATIONS

Colin F. Mackenzie, Horst RL, Mahaffey DL and LOTAS Group. Group decision-making during trauma patient resuscitation and anesthesia. 37th Human Factors and Ergonomic Society Meeting. Seattle, Washington, October 12-15, 1993.

Colin F. Mackenzie and LOTAS Group. Trauma Patient Airway Management. 68th Clinical and Scientific Congress of the International Anesthesia Research Society, Orlando, Florida, March 5-9, 1994.

Colin F. Mackenzie and LOTAS Group. Video camera in the Emergency Room to improve patient care. 14th Myron B. Laver International Postgraduate Course, Trauma Management, Department of Anesthesia, University of Basel, Switzerland, March 18, 1994.

Colin F. Mackenzie and LOTAS Group. Simulation of Trauma Anesthesia, The LOTAS Experience. 6th International Trauma Anesthesia and Critical Care Society. Paris, France, April 22-24, 1994.

Colin F. Mackenzie, Panel Member. Current and Future Applications of Naturalistic Decision-making with Health Care. Naturalistic Decision-making Conference 2, Dayton, Ohio, June 13-15, 1994.

Colin F. Mackenzie, Horst RL and LOTAS Group, presentation and panel member. Team communications reveal the root causes of performance problems observed in airway management of trauma patients. 12th Triennial Congress of the International Ergonomics Association, Toronto, Canada, August 15-19, 1994.

Colin F. Mackenzie and LOTAS Group. Human Factors in Emergencies. Human Error/Human Factors Course at FDA, Bethesda, Maryland, October 6, 1994.

CONTRIBUTED PRESENTATIONS

Craig GR, Forrest FC, Mackenzie CF, Parr MJ, Boehm C, Gorman G LOTAS Group: Performance of Trauma Anesthesiologists Assessed by a Synthetic work environment. Anesthesiology 79:A535, 1993. Presented at the American Society of Anesthesiologists Annual Scientific Meeting, Washington, DC, October 9-13, 1993.

Bernhard WN, Mackenzie CF, Hu PFM, Horst RL, and the LOTAS Group. A video acquisition systems (VASNET®) for remote monitoring of the clinical environment. 9th Asian Australasian Congress of Anaesthesiologists, Bankok, Thailand. November 11-12, 1993.

Martin P, Mackenzie CF and the LOTAS Group. Stressors occurring during Emergency Tracheal Intubation. Emergency Medicine and Critical Care Society Meeting, Cambridge, England, September, 1993.

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ONR ANNUAL PRODUCTIVITY REPORT, 01 OCT 1993 TO 30 SEPT 1994

Send To: DR. SUSAN E. CHIPMAN
OFFICE OF NAVAL RESEARCH
CODE 342 CS
BALLSTON TOWER ONE
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

FAX: (703) 696-1212

Principal Investigator Name: Colin F. Mackenzie, M.D.

Institution: University of Maryland At Baltimore

Project Title: Development and Enhancement of a Model of Performance and Decision-Making Under Stress in a Real-Life Setting

Number of ONR supported:

Papers *published* in *refereed* journals: 3
Papers accepted for publication in refereed journals: _____
Papers or reports in non-refereed journals: 2
Books or book chapters published: -
Books or book chapters in press: -
Papers Submitted in refereed journals: 4

** Attach list of papers and other publications with full citation.**

Number of ONR supported patents/inventions filed 0 **or granted** 0 **, with patent numbers:**

** Attach title and brief description of patents/inventions, if any.**

Number of Presentations:

Invited: 6
Contributed: 3

Trainee Data:

	TOTAL	FEMALE	MALE	MINORITY	NON-US CITIZENS
No. of Grad. Students	4	1	3	-	-
No. of Postdoctorals:	1	-	-	1	1
No. of Undergraduates:	-	-	-	-	-